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ON THE FERTILIZATION OF SEVERAL SPECIES OF LOBELIA.¹

BY WILLIAM TRELEASE.

AMONG our wild flowers few are more conspicuous than the cardinal flower (*Lobelia cardinalis*), which, by its racemes of large, velvety red flowers, attracts many a wanderer into otherwise very unattractive marshes. The large blue lobelia (*L. syphilitica*) forms also a very conspicuous feature of such places in late summer and early autumn, while the Indian tobacco of the herb doctors (*L. inflata*) is known to everybody. In addition to these, some twenty other species grow wild in North America, and lovers of flowers know well the cultivated creeping lobelia (*L. erinus*), with its pretty blue and white flowers. To any observer not a botanist these are easily known as lobelias by their two-lipped flowers with the tube of the corolla split nearly or quite to its base on the upper side, while from the cleft thus formed the stamens project, their anthers being united to form a tube which is frequently bent downward at its extremity, while the style passes through its center.

To one interested in the devices by which nature causes cross-fertilization to be effected, a closer examination will reveal some additional facts. Nectar is so abundantly secreted, in sunshine, within the base of the filaments—which are there split to give access to it—that the basal part of the flower is often quite filled with it. The structure and development of the stamens and pistil are essentially as Prof. Todd has described them in the January number of the *NATURALIST*, but in addition to the shaking of the anthers he mentions, I think that there is sometimes another reason for the discharge of pollen on the back of an insect entering the flower. The style is in contact with the stamens only by its ring of collecting hairs, and a slight upward pressure on the tip of the anther tube would move the anthers backward without moving the style, and would thus imitate the action of a pump

¹ In the *Ann. and Mag. of Nat. Hist.*, 1868, Vol. II, p. 260, is a very good description of the mode of fertilization of the "common blue" *Lobelia*. Hildebrand and H. Müller, in Germany, and Delpino, in Italy, have also described the fertilization of species of this genus; but as their writings are inaccessible to many American readers, it is thought that the following observations, made in the summer of 1878, at the Botanical Laboratory of Cornell University, may be of some interest. The insects were kindly named for me by Dr. Packard and Mr. Cresson.

in which the piston remains stationary while the barrel moves—pollen would be pumped out of the moving anther-tube by the stationary style with its ring of hairs. Moreover, when the staminate stage of the flower (lasting about three days in *L. erinus*) is ended, and the style protrudes from the orifice of the anthers, the hairs on the style become reflexed, thus apparently serving to prevent such pollen as is not infrequently left in the anther tube from falling out upon the papillose stigma when this is unfolded.

In *L. erinus*, and twelve out of fourteen other species, indigenous and foreign, which I examined, I found essentially the relations of corolla and stamens described by Prof. Todd; and in all cases, the lower lip of the corolla is provided at its base with two longitudinal ridges, including between them a guiding groove which leads into the tube of the corolla directly beneath the tip of the anthers (Fig. 1), thus forcing a bee to enter every flower in the same way. In the thirteen cases mentioned the two lobes of the upper lip of the corolla are nearly erect, as if to prevent an insect from creeping back on the tube of the corolla and obtaining nectar surreptitiously through the cleft on its upper side. The corolla-tube is also comparatively broad, and an open passage is left between its lower border and the filaments (Fig. 3), thus giving access to such insects as small bees, which creep boldly into the corolla in order to reach the nectar within its base.

In *L. cardinalis* (Fig. 4) and the Hawaiian *L. macrostachya* the lower lip of the corolla is pendant, and there is but a narrow passage between the corolla-tube and the stamens, which in these species are greatly elongated, with the tip of the anther-tube at a considerable distance from the corolla (Fig. 4). The two lobes of the upper lip of the latter are often horizontal or even deflexed, appearing to serve their purpose best when in these positions. The flowers go through the same dichogamy as the others, but they are adapted to profit by the visits of large Lepidoptera or even of humming birds, since a bee cannot enter the narrow and elongated tube of the corolla, while even if it could it would encounter the tip of the anthers or the protruded stigma only by the merest accident. On the other hand a hawk-moth or humming-bird could easily poise itself before the flower, and, while removing nectar by its long slender proboscis or bill, this would come in contact with the anthers or stigma, since the guiding-

groove of the corolla would force it to visit each flower in such a position as to secure this result.

I have repeatedly watched for hours plants of *L. erinus*, *L. inflata*, *L. kalmii* (Figs. 1 & 2) and *L. syphilitica*, growing in abundance near our laboratory; and on sunny days I have never failed to see them visited by many bees, though I have often watched isolated plants in vain. On *L. erinus* I have seen numerous individuals of *Augochlora pura* and several species of *Halictus*, and with the exception of one individual of the last-named species they always entered the corolla from the front, creeping in bodily if small enough, or forcing their heads in if they could not enter. I always found them well dusted with pollen. The exceptional individual of *Augochlora pura* was seen to visit eight or ten flow-

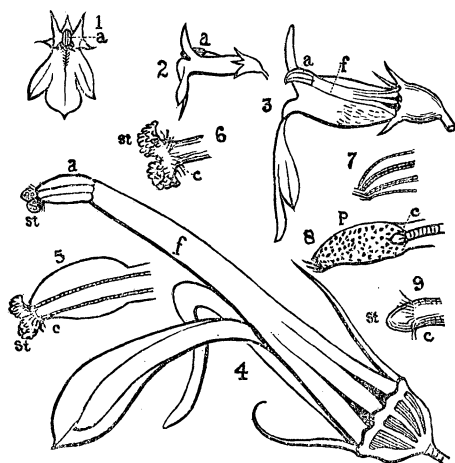


FIG. 1.—*Lobelia kalmii* from in front, slightly enlarged. FIG. 2.—The same from the side. FIG. 3.—Longitudinal section of the same, enlarged. FIG. 4.—Longitudinal section of *L. cardinalis* (X 2). FIG. 5.—Section of anther-tube of flower of *L. kalmii* in the second or pistillate stage, enlarged. FIG. 6.—Stigma of the same, enlarged. FIG. 7.—End of anther-tube of a flower in the first or staminate state, showing the hairs closing its mouth, enlarged. FIG. 8.—Section of the same, enlarged. FIG. 9.—Stigma of the same, enlarged. In all of the figures *a* indicates the anthers; *c*, collecting hairs; *f*, filaments; *p*, pollen; *st.*, stigma.

ers, and it always settled upon the tube of the corolla near its base, and inserted its proboscis through the cleft from which the stamens protrude, thus obtaining the nectar of the flowers without transferring their pollen. Other individuals of this species were seen to visit the flowers properly, and, although unable to creep well into the corolla, they forced their heads in far enough to

reach the nectar with their protruded tongues, and they always transferred pollen. On several occasions I saw small humble bees visit flowers of this species, attracted by their color from neighboring beds of verbenas which they often visited; and one of them when killed and examined under the microscope was found to have its proboscis dusted with oval pollen grains, not to be distinguished from those of this lobelia. For some reason I did not see a single hive-bee on these plants, although where they are abundant they are said to frequent these flowers in large numbers.¹ Twice I saw yellow butterflies (*Colias philodice*) visit these flowers, but though I carefully watched them as, poised on the corolla lip, they sipped the nectar, I could not see that they removed any pollen, their proboscides being slender enough to penetrate the tube without touching the anthers, still, pollen may be carried by them occasionally. On several occasions I saw specimens of a fly (*Calliphora vomitoria*) busily engaged at what appeared to be eating pollen, and their foreheads always came in contact with the anthers or stigma, from both of which, as well as the underlying surface of the corolla, they appeared to gather the pollen. Specimens of another fly (*Syricta pipiens*) were seen repeatedly on the lip of this flower, but I doubt if they were after pollen, and I never saw them come in contact with the anthers or stigma.²

On *L. inflata* I captured only *Augochlora pura* and a species of *Halictus*, but observed many individuals of these species, and believe that I saw at least two other species of quite similar size but very different appearance.

On *L. kalmii* specimens of *Augochlora pura* and two species of *Halictus* were taken.

Very many humble-bees of all sizes, and probably belonging to several species, were seen to visit flowers of *L. syphilitica*, behaving precisely as did the smaller bees on the species previously spoken of. Numerous small bees belonging to several species, chiefly of *Osmia* and *Ceratina*, were also seen to visit these flowers, but they were too small to brush the anthers. On one occasion I saw several individuals of *Ceratina dupla*, a small bee, enter the tube of the corolla, and afterwards retreat. Then,

¹ Darwin, Cross and Self Fertilization, American edition, p. 420.

² Hildebrand has described in the Botanische Zeitung, 1870, p. 638, cases in which the stigmas of this species could not escape from the anther-tube, and, expanding there, were self fertilized.

elevating themselves, they were able to reach the end of the anther-tube, and from this or the protruded stigma they collected small quantities of pollen.

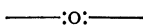
On several occasions I watched a few plants of *L. cardinalis* till twilight with no success, but as this species is not very plentiful in the swamps about Ithaca this is not to be wondered at. Once, however, after watching for several hours, I saw a single ruby-throated humming-bird visit the racemes of six or seven plants that I had collected and placed together in a pool of water within a few feet of the place where I sat. When sipping the nectar the bird balanced itself before the flower, and I could see that its bill always touched the anthers. Being necessarily at too great a distance to see whether there was pollen on its beak, I was obliged to rely upon the examination of a few stigmas, which, in anticipation of this difficulty, I had previously examined and marked. On one of these I found quite a number of pollen grains where previously I had found none. On others, on which pollen had previously been seen, there was plainly more. These cases show that pollen is thus carried, though apparently in small quantities. Though I saw no Lepidoptera visit this species, I see no reason why they should not do so, especially the *Sesias*, and if such be the case they will probably transfer pollen from flower to flower. Where many plants grow together a few observations early in the morning and in the evening will probably prove this to be the case.

To prove the almost self-evident fact that extraneous aid is needed to insure fertilization with the Lobelias, I carefully covered (with gauze nets supported by light frames) two plants each of *L. inflata* and *L. syphilitica*, on each of which I had artificially fertilized the only flowers then in the pistillate state. These flowers set fruit well filled with seed. One of the nets collapsed so as to be in contact with the plant, and several of the flowers of this plant set fruit; but in the two other cases, one of each species, none of the flowers not artificially fertilized produced seed, though their ovaries became more or less swollen. The fourth plant was not observed after being covered. Plants growing uncovered beside these, and others artificially fertilized from time to time and covered by similar nets, were fully fertile, showing that situation or enclosure did not cause this failure to fruit.¹

¹ Darwin also states, Cross and Self Fertilization, p. 364, that *L. ramosa* and *L. fulgens* are quite sterile without insect aid.

As a rule, especially in plants like *L. syphilitica*, which are of simple habit, the flowers are visited by bees from the lowest one of the raceme upward, as has been observed by others to be the case with so many other plants. The humming-bird that I saw visiting *L. cardinalis* also acted in precisely the same way. As the lowest flowers are the oldest, and consequently the only ones in the pistillate stage of development, it is evident that they will usually be fertilized by pollen from a distinct plant, and after they are all fertilized, pollen is taken from flowers situated higher on the raceme for the fertilization of the older flowers of the next raceme visited. With the creeping *L. erinus* I have noticed that bees visit the flowers indifferently, alighting on almost any flower which protrudes from the tangle. But after once alighting they generally adhere to the branch on which this flower is situated, working upward upon it; though this is not invariably the case.

In many species, perhaps all, the style elongates sufficiently to cause the mature stigma to stand at a considerable distance without the anther-tube, thus making it still more certain that it will be brushed by an insect visiting the flower than is the case with the tip of the anthers, for a superabundance of pollen admits of an occasional failure to remove it, but it is imperatively necessary that each stigma be fertilized.



A CONTRIBUTION TO THE ZOÖLOGY OF MONTANA.

BY E. D. COPE.

THE Territory of Montana, taken as a whole, is probably the most valuable tract of land which has not yet been placed under control of a State government, within the limits of the United States. As is well known, the diminished elevation of the Rocky mountains and adjacent plains, as well as the northward bend of the isothermal lines, indicate for Montana a milder climate than that of the Territory of Wyoming on the south, and that of Dakota on the east. Its agricultural wealth is greater than that of either of those Territories, and it is superior to both in the yield of its mines. Timber abounds on its numerous mountain ranges, and it is, par excellence, the range of the large game of North America.

My acquaintance with this region was chiefly obtained through